Mr. Hook's *Anſwer to Monſieur* Auzout's *Conſiderations, in a Letter to the Publiſher of theſe* Tranſactions.

SIR,

Together with my moſt hearty thanks for the favour you were pleaſed to do me, in ſending me an *Epitome* of what had been by the ingenious Monſieur *Auzout* animadverted on a deſcription, I had made of an *Engine* for *grinding ſpherical Glaſſes*, I thought my ſelf obliged, both for your ſatisfaction, and my own Vindication, to return you my preſent thoughts upon thoſe Objections. The chief of which ſeems to be againſt the very *Propoſition* it ſelf: For it appears, that the *Objector* is ſomewhat unſatisfied, that I ſhould propound a thing in *Theory*, without having firſt tried the *Practicableneſs* of it. But firſt, I could wiſh that this worthy Perſon had rectified my miſtakes, not by ſpeculation, but by experiments. Next, I have this to anſwer, that (though I did not tell the *Reader* ſo much, to the end that he might have the more freedom to examine and judg of the contrivance, yet) it was not meer *Theory* I propounded, but ſomewhat of *Hiſtory* and *matter of Fact*: For, I had made trials, as many as my leiſure would permit, not without ſome good ſucceſs; but not having time and opportunity enough to proſecute them, I thought it would not be unacceptable to ſuch, as enjoyed both, to have a deſcription of a way altogether *New*, and *Geometrically* true, and ſeemingly, not unpracticable, whereof they might make uſe, or not, as they ſhould ſee reaſon. But nothing ſurpriſed me ſo much, as, that he is pleaſed (after he had declared it a fault, to write this *Theory*, without having reduced it to practice) to lay it, as he ſeems to do, in one place of his book, *p.* 22 upon the *Royal Society*. Truly, *Sir*, I ſhould think my ſelf moſt injurious to that *Noble Company*, had I not endeavoured, even in the beginning of my Book, to prevent ſuch a miſconſtruction. And therefore I cannot but make this interpretation of what Monſieur *Auzout* ſaith in this particular, that either he had not ſo much of the Language wherein I have written, as to underſtand all what was ſaid by me, or, that he had not read my *Dedication* to the *Royal Society*, which if he had done, he would have found, how careful I was, that that *Illuſtrious Society* ſhould not be prejudiced by my *Errors*, that could be ſo little advantaged by my *Actions*. And indeed, for any man to look upon the matters publiſhed by their Order or Licence, as if they were *Their* Senſe, and had *Their* Approbation, as *certain* and *true*, 'tis extremely wide of their intentions, ſeeing they, in giving way to, or encouraging ſuch publications, aim chiefly at this, that *ingenious conceptions*, and important *philoſophical matter of Fact* may be communicated to the learned and enquiring World, thereby to excite the minds of men to the examination and improvement thereof. But, to return; As to his *Objections* againſt the *Matter*, I do find that they are no more againſt mine, than any other way of *Grinding Glaſſes*; nor is it more than I have taken notice of my ſelf in this Paſſage of the ſame *Paragraph*, of which ſort are alſo thoſe difficulties he raiſes about *Long Glaſſes*, which are commonly known to ſuch, as are converſant in making them. *It would be convenient alſo* (theſe are my words) *and not very chargeable, to have four or five ſeveral Tools: One*, &c. *And, if curioſity ſhall ever proceed ſo farr, one for all lengths, between* 1000. and 10000. *foot long; for indeed, the* Principle *is ſuch, that ſuppoſing* the Mandrils well *made, and of a good length, and ſuppoſing* great care *be uſed in working and poliſhing them, I ſee no reaſon, but that a Glaſs of* 1000. *nay,* 10000. *foot long may be made, as well as one of* 10. *For, the reaſon is the ſame, ſuppoſing the* Mandrils *and* Tools *be made ſufficiently ſtrong, ſo that they cannot bend; and ſuppoſing alſo, that the Glaſs out of which they are wrought, be capable of ſo great a regularity in its parts, as to its Refraction.* But next, I muſt ſay that his *Objections* to me, ſeem not ſo conſiderable, as perhaps he imagines them. For, as to the poſſibility of getting Plates of Glaſs thick and broad enough without veins, I think *that* not now ſo difficult here in *England*, where I believe is made as good, if not much better Glaſs for *Optical Experiments*, than ever I ſaw come from *Venice*. Next, though it were better, that the thickeſt part of a long *Object-Glaſs* were exactly in the middle, yet I can aſſure Monſieur *Auzout*, that it may be a very good

good one, when it is an Inch or two out of it. And I have a good one by me at preſent, of 36. foot, that will bear an *Aperture*, if *Saturn* or the *Moon* in the *twilight*, be look'd on with it, of 3½ Inches over, and yet the thickeſt part of the Glaſs is a great way out of the middle. And I muſt take the liberty to doubt, whether ever my *Animadverſor* ſaw a long Glaſs, that was otherwiſe; as he might preſently ſatisfie himſelf by a way I could ſhew him (if he did not know it) whereby the difference of the thickneſs of the ſides might be found to the hundreth part of a Line.

As to the exceeding exactneſs of the *Figure* of Long *Object-Glaſſes*, 'tis not doubted, but that it is a matter difficult enough to be attained any way: but yet, I think, much eaſier by *Engine*, than by *Hand*; and of all *Engines*, I conceive, none more plain and ſimple, than that of a *Mandril*. And for making *ſpherical Glaſſes* by an *Engine*, I am apt to think, there hardly can be any way more plain, and more exact, than that which I have deſcribed; wherein there is no other motion, than that of two ſuch *Mandrils*, which may be made of ſufficient ſtrength, length, and exactneſs, to perform abundantly much more, than I can believe poſſible to be done otherwiſe than by chance, by a man's hands or ſtrength unaſſiſted by an *Engine*, the motion and ſtrength being much more certain and regular. I know very well, that in making a 60. foot Glaſs by the ſtrength of the hand, in the common way, not one of ten that are wrought, will happen to be good, as I have been aſſured by Mr. *Reeves*; who, I am apt to think, was the firſt that made any good of that length. For the *Figure* of the *Tool* in that way is preſently vitiated by the working of the Glaſs, and without much *gaging* will not do any thing conſiderable. Beſides, the ſtrength of a man's hands, applied to it for the working and poliſhing of it, is very unequal, and the motions made, are very irregular; but in the way, I have ventured to propoſe, by *Mandrils*, the longer the *Glaſs* and *Tool* are wrought together, the more exact they ſeem to be, and if all things be ordered, as they ſhould be, the very poliſhing of the Glaſs, does ſeem moſt of all to rectifie the *Figure*.

As to what he objects, that the Tool does only touch the Glaſs in a *Mathematical Circle*; that is true, perhaps, at firſt, but before the Glaſs is wrought down to its true *Figure*, the *Edge* of the *Tool* will

will be worn or grownd away,ſo as that a Ring of an inch broad may be made to touch the *Spherical Surface* of the Glaſs; nay, if it be neceſſary (without much trouble,eſpecially in the grinding of longer Glaſses) the whole *Concave Surface* of the *Tool* may be made to touch a Glaſs. Beſides,that as to the keeping a quantity of the ſame ſand and Powders of ſeveral fineſses, according as the glaſs wears, the ſame is poſſible to be don,as with the ſame Sand wrought finer by working in the Ordinary way.

The giving the *Inclination* to the *Mandrils*, is not at all difficult; though perhaps to determine the length exactly which the Glaſs ſo made ſhall draw, is not ſo eaſie: But 'tis no matter, what length the Glaſs be of, ſo it be made good, whether 60 or 80 foot, or the like. Nor is it ſo very difficult, to lay them both in the ſame *Plain*. And to keep them *ſteddy*, when once fix'd, is moſt eaſie.

As to the Calculation of the propriety of a Glaſs of a thouſand foot, perhaps for that particular Length, I had not, nor have as yet calculated, that the Convexity of one of eighteen inches broad, will not be above a ſeventh part of a Line. But it does not thence follow, that I had not conſidered the difficulties, that would be in making of it. For,I muſt tell him,that I can make a *Plano convex* Glaſs,though its convexity be of a ſmaler ſphere than is uſual for ſuch a length,to be an *Object-Glaſs* of about 150 foot in Length, nay of 300 foot, and either longer or ſhorter, *without* at all *altering the convexity*. So that, if he will by any Contrivance he hath,give me a *Plano-convex* Glaſs of 20, or 40 foot *Diameter*,without *Veins*, and truly wrought of that *Figure*,I will preſently make a *Teleſcope* with it,that with a ſingle Eyglaſs ſhall draw a thouſand foot: Which *Invention*, I ſhall ſhortly diſcover, there being, I think, nothing more eaſie and certain. And if a *Plano convex* Glaſs can be made of any *Sphere* between twenty and fourty foot *radius*, ſo as that both the *Convex* and *Plain* ſide of the Glaſs be exactly poliſh'd of a true *Figure*,I will ſhortly ſhew, how therewith may be made a *Teleſcope* of any Length, ſuppoſing the Glaſs free from all kind of *Veins*, or inequality of *Refraction*.

As for the ſliding of the Glaſs upon the *Cement*, I ſee no reaſon at all for it, at leaſt in the *Cement*, I make uſe of, having never obſerved any ſuch accident in hard *Cement*. And

And for the Bearing of the *Ring* againſt one ſide of the Glaſs only at a time, I cannot ſee, why *that* ſhould produce any inequality, ſince all the ſides of the Glaſs have ſucceſſively the ſame preſſure.

His ratiocination concerning a Glaſs of 300 foot, is much the ſame with the former, about the difficulty of working a true ſurface of a convenient figure; which how conſiderable both *that* and his Concluſion thereupon (*videl. That we are not to expect Glaſſes of above* 300 *or* 400 *foot long at moſt, and that neither* Matter *nor* Art *will go ſo far*) is, may be judged from what I have newly told you of making any *Object-Glaſs* of any Length.

And for his good wiſhes, that thoſe, who promiſe to make him ſee *Plants* or *Animals* in the *Moon* (of which I know not any, that has done ſo, though perhaps there may be ſome, notwithſtanding his Objections, that do not yet think it impoſſible to be done) had conſidered, what a Man is able to ſee with his *bare* Eye at 60 Leagues diſtance: I cannot but return him my wiſhes, that he would conſider the difference between ſeeing a thing through the *Groſs* and *Vaporous* Air neer the Earth, and through the Air over our heads: Which, if he obſerve the Moon in the *Horizon*, and neer the *Zenith* with a *Teleſcope*, he will experimentally find; and, having done ſo, he will perhaps not be ſo diffident in this matter.

Concerning his Advertiſement to ſuch, as publiſh *Theories*, I find not, that he hath made uſe of it in his own caſe. For, in his *Theory* about *Apertures* he ſeems to be very poſitive, not at all doubting to rely upon it, *vid.* that the *Apertures* muſt be *thus* and *thus* in *great* Glaſſes, becauſe he had found them *ſo* or *ſo* in ſome *ſmall* ones.

For his Propoſal of amendments of ſome inconveniencies in this way, I return him my thanks; but as to his firſt I believe, that the matter may be conteined as wel in the *Concave* Tool, as on the *convex* Glaſs. And as to that of 2 *Poppet-heads*, I do not well underſtand it, if differing from mine; and the keeping of the Tool upon the Glaſs with a ſpring or weight, muſt quickly ſpoyl the whole; ſince, if either of the *Mandrils* will eaſily yield backwards, the *regularity* of *all* will be ſpoiled: and as to the wrigling and playing of the *Mandril*, I do not at all apprehend it.

His

His *Theory* of *Apertures*, though he ſeems to think it very authentick, yet to me it ſeems not ſo cleer. For, the ſame Glaſs will endure greater or leſſer *Apertures*, according to the leſſer or greater Light of the *Object*: If it be for the looking on the *Sun* or *Venus*, or for ſeeing the *Diameters* of the *Fix'd Stars*, then ſmaller *Apertures* do better; if for the *Moon* in the *daylight*, or on *Saturn*, or *Jupiter*, or *Mars*, then the largeſt. Thus I have often made uſe of a 12 foot-Glaſs to look on *Saturn* with an *Aperture* of almoſt 3 inches, and with a ſingle Eye-glaſs of 2 inches *double convex*: but, when with the ſame Glaſs I looked on the *Sun* or *Venus*, I uſed both a ſmaller *Aperture*, and ſhallower *Charge*. And though M^r. *Auzout* ſeems to find fault with the *English* Glaſs of 36 foot, that had an *Aperture* of but 2¼ inches *French*, as alſo, with a 60 foot *Tube*, uſed but with an *Aperture* of 3 inches yet I do not find, that he hath ſeen Glaſſes of that length, that would bear greater *Apertures*, and 'tis not impoſſible, but his *Theory* of *Apertures* may fail in longer Glaſſes.

Of a means to illuminate an Object in what proportion one pleaſeth; and of the Diſtances requiſite to burn Bodies by the Sun.

One of the means uſed by M. *Auzout* to enlighten an Object, in what proportion one pleaſeth, is by ſome great *Object-Glaſs*, by him called a *Planetary* one, becauſe that by it he ſhews the difference of Light, which all the *Planets* receive from the *Sun*, by making uſe of ſeveral *Apertures*, proportionate to their diſtance from the *Sun*, provided that for every 9 foot draught, or thereabout, one inch of *Aperture* be given for the *Earth*. Doing this, one ſees (*ſaith he*) that the Light which *Mercury* receives, is far enough from being able to burn Bodies, and yet that the ſame Light is great enough in *Saturn* to ſee cleer there, ſeeing that (to him) it appears greater in *Saturn*, than it doth upon our *Earth*, when it is overcaſt with Clouds: Which (he adds) would ſcarce be believed, if by means of this Glaſs it did not ſenſibly appear ſo; Whereof he promiſes to diſcourſe more fully in his

Treatiſe